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ABSTRACT

The projection of enrollment changes is vital to the planning of educational facilities. However, existing methods of projecting urban populations fall short of acceptable performance because they fail to adequately take into account residential mobility. As a starting point for improving these methods, this report develops an accounting model of student flows in a large urban school system. The model is used to identify components of change in grade level enrollment for each school and to suggest research designs for investigating processes generating these changes. The model is also intended to be used as a basis for carrying out empirical analyses of student flows in large school systems and for developing improved techniques of projection. (Author/MLF)

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A SIMPLE MODEL OF STUDENT FLOWS IN AN URBAN SCHOOL SYSTEM

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FOREWORD

Modern-day educational planners face an extremely difficult task of providing quality education to large masses of students in view of decreased revenues, soaring costs, shifting populations, and changing educational programs. Such a challenge requires that a far greater emphasis be placed on planning for schools than has been the case to date and necessitates the development of improved techniques specially designed for educational planning.

Project Simu-School is intended to provide an action-oriented organizational and functional framework necessary for tackling the problems of modern-day educational planning. It was conceived by a task force of the National Committee on Architecture for Education of the American Institute of Architects, working in conjunction with the Council of Educational Facility Planners. The national project is comprised of a network of component centers located in different parts of the country.

The main objective of the Chicago component is to develop a Center for Urban Educational Planning designed to bring a variety of people--laymen as well as experts--together in a joint effort to plan for new forms of education in their communities. The center is intended to serve several different functions including research and development, investigation of alternative strategies in actual planning problems, community involvement, and dissemination of project reports.

The projection of enrollment changes is vital to the planning of educational facilities; however, existing methods of projecting urban populations fall short of acceptable performance because they fail to adequately take into account residential mobility. As a starting point for improving these methods, this report develops an accounting model of student flows in a large urban school system. The model is used to identify components of change in grade-wise enrollment for each school and to suggest research designs for investigating processes generating these changes. It is hoped, therefore, that this model will be used as a basis for carrying out empirical analyses of student flows in large school systems and for developing improved techniques of projection.

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Project Manager

A SIMPLE MODEL OF STUDENT FLOWS IN AN URBAN SCHOOL SYSTEM

INTRODUCTION

A common element in the planning of many public facilities such as schools, hospitals, clinics and libraries is the need to locate physical plants of given capacities at a number of different sites within the urban area. Determination of both capacities and sites depends in large part on the distribution of the population to be served and on the technological factors influencing the efficiency of plants of different sizes. Since investment in physical structures is considerable, the planner not only must consider the present distribution of demand for the facility but also must attempt to take projected changes in that distribution into account. If he fails to do this, a facility located in a rapidly changing neighborhood may be faced with the burdens

of excessive congestion or the financial losses associated with unused capacity very soon after its construction.

Development of a capability to produce reliable projections of short-run changes in the distribution of demand is critical to effective facility planning. Despite the recognition of this fact not only in the field of education (Stone, 1970) but also in the planning of health services (Gross, 1971), existing methodologies are weak, particularly when data are required for small areas*. The prime purpose of this paper is to establish a basis for improving the methodology for predicting short-run changes in distribution of demand for school facilities.

The premise on which this paper is founded is that residential mobility is the immediate cause of the majority of change in distribution of the population of a large city. Although some longer run changes can be projected on the basis of ageing of a relatively stable population with known demographic characteristics, the majority of shifts in population distribution are effected by relocation of households within the city. Our experience tells us that many types of relocation have important consequences for the school system: the move of the growing family to the suburb, the influx of blacks into racially changing neighborhoods, and the arrival of the rural migrant

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*by small area we mean areas such as census tracts, community areas, school districts or other sub-divisions of single urban areas

in the central city. However, if we are to evaluate the consequences of these diverse events for the planning of school facilities, we need a common framework into which these events can be placed and within which they can be interpreted.

We approach the problem of providing such a framework by developing a model of student flows within a large urban area. The essential feature of the model is the representation of transfer rates between grades and between school districts as conditional probabilities of being in a given district and grade at the beginning of a specified time period given that the student was in a specified grade and district at the beginning of the previous time period.

The model serves three specific functions related to the overall purpose of the paper:

(1) It provides a coherent statement of the types of student flows experienced within the school system. In particular, it identifies those flows which make a direct contribution to changes in grade enrollment in a given school district.

(2) The model provides a basis for interpreting our existing knowledge of residential mobility in the city in terms relevant to facility planning. This is not an easy task as the majority of research in this area has been concerned with the population as a whole* rather than with the sub-group comprising

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* see Simmons (1968) for a good general review.

households with school-aged children. However, by identifying the properties of student flows which stimulate change in enrollment (the model parameters) we indicate the path to be followed in linking student mobility and residential mobility as a whole.

(3) It provides a framework for collecting and organizing data to evaluate the consequences of particular planned or unplanned changes taking place at the neighborhood level. The planner is often concerned with anticipating the effects of events such as the location of a new freeway or an industrial park, or the impact of continuing change in the ethnic composition of an area. At present, we have little on which to base such evaluations. The model suggests that one strategy is to attempt to identify typical patterns of student flows (and hence particular values of model parameters) associated with known events. In particular, it provides a framework for integrating and developing the concept of area studies.

The paper is organized into three sections. Section I is concerned with the development of the model. Section II discusses the implications of the model for evaluating changes in school enrollment and for interpreting the results of studies of residential mobility in terms relevant to facility planning. The final section presents a series of suggestions for research which are a logical outcome of the structure of the model.

I

A SIMPLE MODEL OF STUDENT FLOWS IN AN URBAN SCHOOL SYSTEM

Assuming that the distribution of school-age children between public and private schools by grade and district is known at the beginning of the school year, we wish to develop a model of student transfers (flows) during the subsequent year which would enable us to define the distribution of school-age children at the beginning of the following year.

We begin by considering the individual student. As Table I shows, many events can occur during the year which affect the position of the student in the school system. Given the number of students and the number of school districts in a city the size of Chicago, we need to make a number of simplifying assumptions in order to develop a useful representation of the system of student transfers. We first examine the flows for a single school and subsequently develop a model for a multi-school system.

TABLE I

POSSIBLE EVENTS EXPERIENCED BY STUDENTS IN A GIVEN GRADE IN A SINGLE PUBLIC SCHOOL DURING A SCHOOL YEAR

A. Input to i-th grade at beginning of school year.
   - (i) students advancing from grade i - 2 in same school;
   - (ii) students advancing from grade i - 1 in same school;
   - (iii) students remaining in grade i from previous year in same school;
   - (iv) new entries to school, which can be:
     - (a) student's first time in school;
     - (b) transfer from another public school in same district;*
     - (c) transfer from private school in same school district;

(d) transfer from being "out of school" in same district;
(e) transfer from public school in another district in same board area;
(f) transfer from private school in another district in same board area;
(g) transfer from being "not in school" in another district in same board area;
(h) transfer from outside board area.

B. Events occurring during school year.
(i) student stays in same grade all year;
(ii) student promoted to grade i + 1 during year;
(iii) student drops out of school;
(iv) student has education suspended due to accident, illness, etc.;
(v) student transfers to another public school in same district;
(vi) student transfers to private school in same district;
(vii) student transfers to public school in another district within same board area;
(viii) student transfers to private school in another district in same school area;
(ix) student transfers to "not in school" in another district in same school area;
(x) student transfers out of board area.

(Each of events B(i)-B(x) can occur to students who enter grade i during the year under each type of entry A(iva)-A(ivh).)

C. Events occurring at the end of the school year.
(i) student remains in grade i;
(ii) student is promoted to grade i + 1; depends on
(iii) student is promoted to grade i + 2; value of i
(iv) student graduates;
(v) student drops out in same school district;
(vi) student transfers to another public school in same district;
(vii) student transfers to private school in same district;
(viii) student transfers to public school in another district in same board area;
(ix) student transfers to private school in another district in same board area;
(x) student transfers to "not in school" in another district in same board area;
(xi) student transfers out of board area.

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*Events A(ivb), (ivc), (ive), (ivf) can be made grade-specific by origin, events B(v), (vi), (vii), (viii) grade-specific by destination, and events C(vi), (vii), (viii), (ix) grade-specific by destination.

State of School-Age Child at time t+1 who was in District at time t.

State of School-Age Child at time t in District

Grade	1	2	3		i		n	In private school	Not in school	Transfer to other school district	Transfer to private school in other school district	Migrate out of Board area	Graduate
1	m_{11}	m_{12}	m_{13}	0	0	. . . . .	0	m_{2P}	m_{1N}	m_{1A}	m_{1R}	m_{1E}	0
2	0	m_{22}	m_{23}	m_{24} . . .	0	. . . . .	0	m_{2P}	m_{2N}	m_{2A}	m_{2R}	m_{2E}	0
i	0	0	0	 0	m_{ii}	$m_{i,i+1}$ $m_{i,i+2}$. 0 .	0	m_{iP}	m_{iN}	m_{iA}	m_{iR}	m_{iE}	0
n	0	0	0	. . . . .	0 .	 0	m_{nn}	m_{nP}	m_{nN}	m_{nA}	m_{nR}	m_{nE}	m_{nG}
In private school	m_{P1}	m_{P2}	. . .	. . . . .	m_{Pi}	. . . . .	m_{Pn}	m_{Pp}	m_{PN}	m_{PA}	m_{PR}	m_{PE}	m_{PG}
Not in school	m_{N1}	m_{N2}	. . .	. . . . .	m_{Ni}	. . . . .	m_{Nn}	m_{NP}	m_{NN}	m_{NA}	m_{NR}	m_{NE}	0
Transfer from other school district	m_{A1}	m_{A2}	. . .	. . . . .	m_{Ai}	. . . . .	m_{An}	m_{AP}	m_{AN}				
Transfer from private school in other school district	m_{R1}	m_{R2}	. . .	. . . . .	m_{Ri}	. . . . .	m_{Rn}	m_{RP}	m_{RN}				
In-migrant from outside Board area	m_{E1}	m_{E2}	. . .	. . . . .	m_{Ei}	. . . . .	m_{En}	m_{EP}	m_{EN}				
First time student	m_{F1}	0	. . .	. . . . .	0	. . . . .	0	m_{FP}	m_{FN}				

Exogenous Inputs at t+1

FIGURE 1:

A TABULATION OF STUDENT FLOWS FOR A SINGLE SCHOOL DISTRICT

A. A School District with one Public School

First, we consider the case of a single school district with one public school of n grades. At the beginning of the school year (say year t) each school-age child resident in the district is either enrolled in one of the n grades, or is enrolled in a private school, or is not in the school at all. If we make the following assumptions: (1) that no students come into the school and go out again during the year, and (2) that no child can be promoted by more than two grades at the end of the year, the set of events occurring to students at the school from the beginning of year t to the beginning of year t + 1 can be represented as in Figure 1.

In our representation, the majority of entries are logically zero; the change in enrollment in grade i from year t to year t + 1 is given by the expression,

$$\Delta m(t,t+1) = (m_{i-2,i} + m_{i-1,i} + m_{ii} + m_{Ai} + m_{Ri} + m_{Ei} + m_{Fi} + m_{Pi} + m_{Ni}) - m_{i.} \quad (1)$$

where $m_{i.}$ is the total enrollment in grade i at the beginning of year t.

Educationalists are often interested in the degree of student-specific stability in classroom enrollment as well as in change in total numbers. In other words, concern is expressed for the level of turnover of students in a given class, a variable which may be closely related to a number of problems such as the maintenance of discipline or the rate of deterioration of books and equipment. The simplest measure, which can be derived directly from Figure 1 is the inter-annual stability

in classroom enrollment (IS_i in grade i), where

$$IS = \frac{m_{i,i+1}}{m_{i.}} \qquad (2)$$

In most cases, IS_i will be an appropriate measure of stability; however, when turnover rates are high with many students coming into grade i and leaving grade i during the year, expression (2) will seriously underestimate the degree of turnover (or conversely overestimate the degree of stability). A number of alternate measures are possible:

(i) IS_i can be defined over a shorter time period such as a quarter or even a month.

(ii) a value m_{ii}^* can be defined which represents the number of students who begin the school year and finish the school year in the same grade. A measure of intra-annual stability is then given by

$$AS = \frac{m_{ii}^*}{m_{i.}} \qquad (3)$$

(iii) two values may be defined: m_{Ii} is the total number of students transferring into grade i during the year and m_{0i} is the total number of students transferring out of grade i during the year. Intra-annual class turnover is then defined as

$$AT_i = \frac{m_{Ii} + m_{0i}}{2\bar{m}_i} \qquad (4)$$

where $\bar{m}_i$ is the average size of the ith grade during the year.

An important point to note is that there is no necessary relation between degree of class stability and change in enrollment. With regard to expressions (1) and (2), we might have a high out-movement flow (and hence low stability) which is compensated by a high in-movement flow and, therefore, no net change in enrollment during the year. Conversely, in an area in which stability is high, a large in-movement of students with no compensating out-movement will produce significant changes in enrollment. The main implication of these statements is that although classroom stability rates may be of interest, they are of little value in evaluating changes in enrollment levels unless they can be related to broader processes of population redistribution of which they are a part.

B. A School System with m School Districts

The structure of Figure 1 can be readily extended to provide a model of student flows for a school system with m school districts. For the sake of simplicity, we will assume that each district comprises one public school with n grades, but the structure is easily modified to cope with the case of several public and private schools in each district (it merely becomes more cumbersome to represent). The

model of the entire system is developed in three stages.

(i) Consider a single district which we shall call district j. Instead of representing transfers to other school districts from grade i as m_{iA} as in Figure 1, we can identify the flows by specific origin grade and district and specific destination grade and district. The value ${}_{jk}m_{ih}$ is defined as the number of students who are in grade i in district j at the beginning of the observation period and are in grade h in district k at the beginning of the next observation period. Similarly, the value m_{iR} is replaced by the values ${}_{jk}m_{iP}$ which represent the number of students who are in grade i in district j at the beginning of the observation period and are in a private school in district k at the beginning of the next period.

(ii) Since both school districts and individual grades within the schools exhibit a considerable amount of variability in size, the absolute numbers contained in Figure 1 and in the extension outlined in (i) need to be standardized for further analysis. In particular, we are concerned with the rates at which different events occur in different school districts. We can define the inter-observation period transfer rates* from the ith grade in district j by dividing

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* these rates ignore transfers into and out of the ith grade in district j during the observation period.

each value in the appropriate row of our representation by $_{j}m_{i.}$ which is the total enrollment in grade i in district j at the beginning of the year.** We therefore define a new set of values

$$_{jk}P_{ih} = \frac{_{jk}m_{ih}}{_{j}m_{i.}} \qquad (5)$$

which are the proportions of those students starting in grade i in district j at the beginning of the observation period who are in grade h in district k at the beginning of the next period.+

The model structure outlined in this stage is presented in matrix form in Figure 2. To simplify the presentation, the larger matrix is divided into a series of sub-matrices and vectors. Each matrix refers to flows between the origin district and a specific destination district and the vectors E_j and G_j refer to out-migrants from the entire board area

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** if the size of the grade class changes markedly during the observation period, $_{j}m_{i}$ can be re-defined as the average size of the class during this period.

+ note that the values $_{jk}P_{ih}$ may be interpreted as the conditional probability of being "enrolled in grade h in district k at the beginning of the next period given that the student was enrolled in grade i in district j at the beginning of the previous period". However, for this interpretation to be of value, we must be able to demonstrate that these probabilities exhibit some form of predictable behavior over time (either being stationary or being some specified function of other predictable variables).

and to graduates respectively. Thus, the matrix P_{jj} refers to the grade-specific rates of exchange within district j and the matrix P_{jk} to grade-specific rates of exchange between the jth and kth districts.*

(iii) Finally, we expand the system to include all m districts as origins. This system is represented in Figure 3 in terms of matrices and vectors. Each matrix represents the rates of grade-specific transfers between the districts indicated by the matrix subscripts.

We represent the in-migrants from outside the board area and the number of new students separately and in absolute numbers. If special surveys were taken it would be possible to include new students within the model by defining an additional "grade" of pre-school children in each district. However, in the case of in-migrants, we cannot define the base population for the calculation of in-migrants strictly as an exogenous input.**

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* we note that the row sums in Figure 2 are all unity, i.e.

$$\left(\sum_k \sum_h {}_{jk}P_{ih}\right) + {}_jP_{iE} + {}_jP_{iG} = 1 \text{ for all j and all i}$$

** see Moore (1971) for further discussion of the problems of treating in-migrants to the city.

State of School-Age Child at time t+1

State of School-Age Child in District j at time t

		1	2		i		n	In private school	Not in school		1	2		i		n	In private school	Not in school		Out-Migrants from Bd. area	Graduates
1	. . . .	$^{j}P_{11}$	$^{j}P_{12}$	. . .	0	. . .	0	$^{j}P_{1P}$	$^{j}P_{1N}$	. . .	$^{jK}P_{11}$	$^{jK}P_{12}$	. . .	0	. . .	0	$^{jK}P_{1P}$	$^{jK}P_{1N}$	. . . .	$^{j}P_{1E}$	0
2	. . . .	0	$^{j}P_{22}$	. . .	0	. . .	0	$^{j}P_{2P}$	$^{j}P_{2N}$	. . .	0	$^{jK}P_{22}$	. . .	0	. . .	0	$^{jK}P_{2P}$	$^{jK}P_{2N}$	. . . .	$^{j}P_{2E}$	0
. . . .		. . . .																			
i	. . . .	0	0	. . .	$^{j}P_{ii}$	. . .	0	$^{j}P_{iP}$	$^{j}P_{iN}$	. . .	0	0	. . .	$^{jK}P_{ii}$	. . .	0	$^{jK}P_{iP}$	$^{jK}P_{iN}$	. . . .	$^{j}P_{iE}$	0
. . . .																					
n	. . . .	0	0	. . .	0	. . .	$^{j}P_{nn}$	$^{j}P_{nP}$	$^{j}P_{nN}$	. . .	0	0	. . .	0	. . .	$^{jK}P_{nn}$	$^{jK}P_{nP}$	$^{jK}P_{nN}$	. . . .	$^{j}P_{nE}$	$^{j}P_{nG}$
In private school		$^{j}P_{P1}$	$^{j}P_{P2}$	. . .	$^{j}P_{Pi}$		$^{j}P_{Pn}$	$^{j}P_{PP}$	$^{j}P_{PN}$	. . .	$^{jK}P_{P1}$	$^{jK}P_{P2}$	. . .	$^{jK}P_{Pi}$	. . .	$^{jK}P_{Pn}$	$^{jK}P_{PP}$	$^{jK}P_{PN}$		$^{j}P_{PE}$	$^{j}P_{PG}$
Not in school		$^{j}P_{N1}$	$^{j}P_{N2}$	. . .	$^{j}P_{Ni}$		$^{j}P_{Nn}$	$^{j}P_{NP}$	$^{j}P_{NN}$	. . .	$^{jK}P_{N1}$	$^{jK}P_{N2}$	. . .	$^{jK}P_{Ni}$	. . .	$^{jK}P_{Nn}$	$^{jK}P_{NP}$	$^{jK}P_{NN}$		$^{j}P_{NE}$	0

Matrix Pjj of transfer rates within District j

Matrix PjK of transfer rates between Districts j and K

Vector Ej of out-migrants from j

Vector Gj of gradustes from j

FIGURE: 2
INTER-DISTRICT TRANSFER RATES FOR STUDENTS ORIGINATING IN DISTRICT J

Destination District at time t+1

Originating District at time t

	1	2		j		k		m	Out-Migrants from Board area	Graduates
1	P_{11}	P_{12}	. . .	P_{1j}	. . .	P_{1K}	. . .	P_{1m}	$E_{1.}$	G_1
2	P_{21}	P_{22}	. . .	P_{2j}	. . .	P_{2K}	. . .	P_{2m}	$E_{2.}$	G_2
j	P_{j1}	P_{j2}	. . .	P_{jj}	. . .	P_{jK}	. . .	P_{jm}	$E_{j.}$	G_j
k	P_{K1}	P_{K2}	. . .	P_{Kj}	. . .	P_{KK}	. . .	P_{Km}	$E_{K.}$	G_K
m	P_{m1}	P_{m2}	. . .	P_{mj}	. . .	P_{mK}	. . .	P_{mm}	$E_{m.}$	G_m

Exogenous Inputs (Absolute Values)

In-Migrants to Board area	$E_{.1}$	$E_{.2}$		$E_{.j}$		$E_{.K}$		$E_{.m}$
New Students	F_1	F_2		F_j		F_K		F_m

FIGURE: 3
MATRIX REPRESENTATION OF INTER-DISTRICT TRANSFER RATES FOR AN M DISTRICT SYSTEM

II

UTILITY OF THE FLOW MODEL

In this section we are concerned with the implications of the structure of the model we have developed. The section is divided into two parts: (A) the implications of the structure for the study of capacitative changes in school enrollment, and (B) the processes which generate particular values of the model parameters (the values ${}_{jk}P_{ih}$).

A. Capacitative Changes in Enrollment

Four sets of values are important in the construction of forecasts of changing enrollment by grade and by district:

(i) Variation within individual schools due to the ageing of classes of different sizes. Given that both existing class enrollments and age-group survival rates are well known, projection of changes in grade-specific enrollment from this source pose no problem.

(ii) Variation within the school district due to net transfers between public and private schools and the "not in school" sector. As DeVise's (1970) study of Oak Park demonstrated, reduced enrollment in parochial schools may be a major source of change; ability to predict these values depends on developing an understanding of the educational problems existing within each school district.

(iii) The net balance of transfers into and out of each school district. Three basic situations arise:

(a) The district exhibits virtually no change as inflows and outflows are in balance.

(b) The district is subject to slow and continuing change due to ongoing processes such as the net suburbanization of inner city families. Such changes are evidenced in the consistency of exchange rates over a number of consecutive observation periods and may be used in the construction of short-run projections by extrapolation.

(c) The district experiences sudden shifts in the composition and number of its school-aged population. These shifts are of two types:

Planned Changes as in the case of urban renewal projects which specify the shifts in number and characteristics of the neighborhood population.

Unplanned Changes as in the case of sudden alteration in the physical environment or in the socio-cultural values attributed to the area. The case of ghetto expansion is obviously the most dramatic, but other instances such as the influx of young couples into inner city areas with high amenity value, or the sudden changes which sometimes accompany the location of public facilities (such as an expressway) cannot be ignored. These population shifts are

unpredictable in the sense that the particular magnitude and location cannot be specified, although we can often make a priori statements regarding the types of area in which such events might occur (and sometimes attach useful subjective probabilities of occurrence for different areas).

(iv) Variation within the school district due to changes in the influx of new students into the public school system (the values $_{j}m_{F1}$). In the short-run, these values can be estimated satisfactorily by means of surveys of the number of pre-school children in the district. In the longer-run, or in the case of rapidly changing neighborhood population, reliable forecasts depend on an understanding of the types of movement behavior discussed in (iii) above.

The above discussion highlights the fact that the model parameters which are of importance in constructing district-specific forecast will vary from one district to another. In many cases, where class enrollment exhibits a fairly high level of stability, the important variable is the influx of new students ($_{j}m_{F1}$). In other cases, where enrollments are changing markedly in terms of both size and composition, the model serves as a basis for specifying the flows to be monitored rather than as a mechanism for making forecasts; as information relating to flows for rapid change situations is

acquired, improved capabilities for making short-run projections will be attained.

B. The Processes Generating the Values $_{jk}P_{ih}$

The parameters of the model (the values $_{jk}P_{ih}$) may be treated either individually or collectively as dependent variables. In other words, we are concerned with the factors which underly particular flow parameters. Such a treatment of model parameters is directly related to the bulk of existing research on residential mobility which is concerned both with the propensity of individual families to move and with the structure of inter-area flows within the city. Since the literature is vast and problems are encountered in translating the results of this research into terms relevant to the school-aged population, detailed treatment will be postponed for a subsequent paper. However, in brief, two separate approaches may be defined:

(i) The treatment of the individual parameters as dependent variables in a regression analysis. Particular attention has been focused on the factors affecting the propensity to move (see, for example, Butler et. al., 1969) which is related to the stability values $_{jj}P_{i,i+1}$. The values $_{jk}P_{ih}$ have also been extensively analysed, particularly in terms of the level of accessibility between areas j and k (see, for example, Olsson (1965) as well as DeVise's (1970) observation that transfers from neighboring South Austin accounted for the majority

of students transferring into Oak Park from other public schools).

(ii) The disadvantages of the approach outlined above are that it is static and it is concerned with form rather than process. Although the above procedure can give useful insights, a more critical approach relating mobility and neighborhood change processes is demanded if we are concerned with anticipating changes in population at the neighborhood level. Figure 4 presents a simple cross-classification in terms of mobility and change characteristics which can be used to identify "typical change situations". It is the Type I situations which pose the greatest problem for planning of any public facilities.

	Change in Population Characteristics of Neighborhoods	Stability in Population Characteristics of Neighborhoods
High Mobility	I a) Rapid change resulting from ethnic, social or racial conflict within area. b) Change resulting from area being assigned high social value by specific subgroup c) Change resulting from rapid deterioration of physical environment due to facility location.	II a) Inflexible housing catering to small range of household type; high mobility maintains specialized character. b) Neighborhood is transit area for in-migrants from rural areas and other urban areas.
Low Mobility	III a) Flexible housing, particularly suburban single family houses. Slow ageing of population; selective out-migration by age. b) Deteriorating housing leading to downgrading of socio-economic characteristics. Selective in-migration by socio-economic class.	IV a) Tightly structured social networks, particularly for ethnic communities, tie individual to neighborhood.

FIGURE 4: TYPICAL SITUATIONS LINKING MOBILITY AND POPULATION CHANGE AT THE NEIGHBORHOOD LEVEL.

III

SUGGESTED TOPICS FOR FURTHER RESEARCH

In the previous sections we have presented a simple model of student flows in an urban school system and discussed its relevance for evaluating changes in grade enrollment for different school districts. However, we must admit that, at the present time, we know relatively little about either the values of the model parameters in individual cases or the factors which generate changes in these parameter values. Much research needs to be undertaken before a marked improvement is attained in methods of projecting short-run changes in the distribution of demand for school facilities and it is logical to use the structure of the model to organize that research.

Considerable returns can be anticipated from calibrating the model for one segment of the school system in a large urban area such as Chicago. Determination of the values of the model parameters in a real situation will provide a much sharper picture of the dynamics of grade-specific enrollments than is usually available. In other words, the model provides the basic structure for the development of a coherent data system regarding student flows in an urban area. Preferably, this structure should be developed first for a single school district to determine more specifically the problems which arise in evaluating the individual parameters.

However, although accurate description is a very desirable asset, in itself it would not justify the expenditure.

The model must also yield insights into the processes underlying changing school enrollment. Using the model structure we can identify a further set of interesting problems:

(1) A basic planning question is "what are the consequences of specific location decisions on the distribution of the urban population?" In particular, the planner is concerned with the consequences of building a new expressway or airport or zoning peripheral land for industrial development. In the present situation, we are concerned with the impact of these actions on school enrollment. One research strategy for identifying these consequences is to select known facility location decisions within the urban area in the recent past and to examine the model parameters for those districts affected by the action. The basic objective is to identify common patterns in parameter values associated with given types of public action.

(2) In a similar vein to (1), we can seek to identify the nature of model parameters in known cases of "unplanned changes" such as are associated with ghetto expansion or with rapidly upgraded social status of inner city areas.

(3) Taking the converse situation to (1) and (2), we may select specific districts within the urban area based on locational (suburban-central city) and

growth (decline-stable-growth) characteristics and treat them as case studies. Temporal variation in model parameters would be of major interest with emphasis placed on identifying both stationarity and sudden shifts in parameter values.

(4) Particular parameters of educational interest may be selected for study in terms of district by district variation. In particular, correlation analysis of district-by-district variation in stability rates, drop-out rates and private school-public school transfer rates may lead to new insights regarding the structure of student flows.

(5) An important property of the model we have presented is that it is developable. The structure in Figure 3 is similar to the general m-region population growth model of Rogers (1968); with only minor modifications it could be made compatible with the markov renewal formulations presented recently by Ginsburg (1971). The utility of these models depends on the stationarity of the model parameters. One of the tasks of initial research is to determine the extent to which such stationarities exist and thereby assess the degree to which formal analysis of the model is likely to prove fruitful. However, for some situations, we may wish to evaluate the consequences for the school system of transfer rates being perpetuated for a number of years into the future. Using Rogers'

model, the implications of a given schedule of transfer rates for generating changes in the distribution of children in the system can be evaluated. This may serve to identify those areas in which action is most drastically needed, or, at the very least, those areas for which the mobility experience needs to be most carefully monitored. Thus, the final project suggested is an evaluation of the consequences of hypothesized mobility experiences for selected problem districts within the city to establish bounds on short-run enrollment changes.

A FINAL COMMENT

This paper is meant to be a starting point. The projection of short-run changes in the distribution of demand is essential to effective facility planning. At present, methodologies are weak, primarily due to a woeful lack of understanding of the processes by which such distributions change. We desperately need data on the structure of student flows under varying conditions, but data collected in a haphazard fashion are of little value. The model presented in this paper indicates some types of data which should be collected and ways in which these data can be used. Undoubtedly, as research related to the model proceeds, the information and understanding acquired will lead to modification and refinement of the model and to new data specifications. However, such advances can only arise from working initially within a more general structure such as that presented here.

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